REMARKS

1. Claim 19 was objected to. Claim 19 is amended as required by the Examiner.

2. Claims 13, 15, 16, 25-31, 37-39, 41-44, 46, 47, 49, 50 were rejected under 35 U.S.C. 112, second paragraph. The claims are amended taking into account the Examiner's suggestions in a telephone interview held on June 21, 2004.

More particularly, the Examiner objected to the recitation "a rotational member for rotating with an article held in the end effector" in Claims 13 and 15. Claim 13 is amended to depend from a new Claim 52, which is supported by the original disclosure as follows:

> a rotational member **(ring 270 in Fig. 10)** rotatable around a first axis **(axis passing through body 220)** which is stationary relative to the body, … the rotational member being for contacting and rotating the article **(120)** held by the end effector around the first axis …

See also Fig. 2. Claim 52 is not limited to the embodiments discussed herein.

Per the telephone interview, the phrase "article held in the end effector" is replaced with "article held <u>by</u> the end effector" throughout.

Claim 15 is amended to recite "a rotational member for contacting and rotating an article held by the end effector".

The Examiner states that the recitation of a rotational member rotating "in the end effector" is unclear in Claim 13. New Claim 52 recites a rotational member rotating "relative to the body" of the end effector.

Claims 43 and 44 are canceled.

Claims 25, 38, 41, 43, 46, 49 were rejected due to the recitation "the member is movable relative to the body in a direction opposite from the article". The phrase "opposite from the article" is replaced with "away from the article" per the telephone interview.

3. Claims 13, 15-18, 25, 27, 32, 37, 38, 40, 41, 43, 45, 46, 48, 49 were rejected under 35 U.S.C. 102(b) over Matsuyama (JP 612544437 A). Claims 19, 20, 28-31, 33-36

were rejected under 35 U.S.C. 103(a) over Matsuyama in view of Casarotti et al. (U.S. patent 6,631,935).

Claim 13 depends from new Claim 52. Claim 52 is directed to an end effector which allows adjusting a rotational orientation of an article while the article is held by the end effector. Claim 52 recites a rotational member "rotatable relative to the body" of the end effector around an axis which is "stationary relative to the body".

For example, in Fig. 10, ring 270 rotates relative to body 220, e.g., body 220 may be stationary when the ring rotates, or the body may also move but the ring may undergo a rotational motion relative to the body. Ring 270 rotates around an axis stationary relative to the body, e.g. the vertical axis passing through the body center. The axis is stationary if the body is stationary, and the axis moves with the body if the body moves.

Claim 52 is not limited to the embodiments discussed herein. For example, in some embodiments, the body may rotate when the rotational member is stationary.

Enclosed is an English translation of Matsuyama. Fig. 3 of Matsuyama illustrates a vacuum wafer chuck (see the English translation, page 2, lines 14-24). There is no teaching of a rotational member rotatable relative to the chuck's body of Fig. 3 around an axis passing through the body as recited in Claim 52.

Matsuyama's Fig. 4 shows a Bernoulli chuck (translation, page 2, lines 39-44). This chuck also does not have a rotational member as in Claim 52.

Figs. 1 and 2 show another wafer chuck, having a chucking surface 11. In the cross section Figs. 1(a) and 2, surface 11 appears to be separate from the top portion of the chuck, but surface 11 may be connected to the rest of the chuck in another cross section. In any case, Matsuyama does not teach or suggest that the surface 11 rotates relative to the top portion of the chuck as recited in Claim 52.

Casarotti was cited in connection with Claims 19, 20, 28-31, 33-36 for teaching an end effector attached to a robot arm for handling wafers at stations. Casarotti is no more pertinent to Claim 52 than Matsuyama.

Claim 15 recites a body relative to which a rotational member and an article held by the end effector are rotatable. Claim 15 further recites a device for pressing the article against the rotational member, wherein the device comprises a vortex chuck mounted in the body to emit a gas vortex towards the article.

Matsuyama does not teach or suggest a rotational member for contacting and rotating an article such that the rotational member and the article rotate relative to the body as in Claim 15. Casarotti is no more pertinent.

Claim 16 depends from Claim 15.

Claims 17-20 depend from Claim 52.

Claim 25 also depends from Claim 52, and further recites that "in addition to being rotatable around the first axis, the rotational member is movable relative to the body in a direction away from the article to yield when … the end effector presses the … surface of the article against a … surface not belonging to the article and not belonging to the end effector". Claim 25 is supported by Applicants' specification, page 6, lines 27-33. In that embodiment, when the end effector places the wafer 120 on a dicing tape or some other surface, and the end effector body 220 moves down, the gas emitted from vortex chucks 230 (Fig. 5) presses the wafer down and the wafer could be damaged. Ring 270 yields up relative to body 220 and relieves the pressure on wafer 120.

Claim 25 is not limited to the embodiments discussed herein. For example, the article could be placed on a non-horizontal surface, or could be located above the end effector and pressed upward. Other embodiments are also possible.

There is no teaching of a yielding rotational member in Matsuyama or Casarotti as recited in Claim 25.

Claims 27-31 depend from Claim 52.

Claims 32-37 depend from Claim 15.

Claim 38 depends from Claim 15, and further recites that the rotational member can yield. See the discussion above in connection with Claim 25.

Claims 40, 41, 45, 46 depend from Claim 52. In addition, Claims 41 and 46 each recite a yielding rotational member. See the discussion above in connection with Claim 25.

Claim 49 recites a yielding rotational member. See the discussion above in connection with Claim 25.

New Claim 51 depends from Claim 15.

Claim 52 was discussed above.

Claims 53 and 54 depend from Claim 52. In Claim 54, the "rotation device external to the end effector" reads on device 610, 620 (Applicants' Fig. 10 and specification, page 5, lines 29-32). Claim 54 is not limited to the embodiments discussed herein.

Any questions regarding this case can be addressed to the undersigned at the telephone number below.

I hereby certify that this correspondence is being deposited with the United States Postal Service as First Class Mail in an envelope addressed to: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450, on July 28, 2004.

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(54) Title of the Invention WAFER CHUCK
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SPECIFICATION

1. Title of the Invention

WAFER CHUCK

2. Patent Claims

A wafer chuck, characterized in that it comprises a chucking surface with a surface area less than that of the wafer which is to be chucked, radial grooves are provided in said chucking surface, a portion on the circumference of said chucking surface, which faces said wafer which is to be chucked, is recessed, a plurality of gas ejection orifices are provided in said recessed portion, gas is ejected from the gas ejection orifices in the direction of wafer edge, and the wafer is chucked to said chucking surface.

3. Detailed Description of the Invention

[Field of the Invention]

The present invention relates to a wafer chuck used for handling a semiconductor wafer in the process for the fabrication of a semiconductor device.

When semiconductor devices such as IC are fabricated, handling of semiconductor wafers in the wafer process is an important factor affecting the production yield. Thus, it is very important to handle the substrate so as to prevent the contamination

and damage of the surface where transistor elements will be formed. For this purpose, vacuum chucks have been used. The vacuum suction chucks are called wafer chucks. Wafer chucks are tools designed to chuck a wafer from the rear surface by vacuum suction in order to move or fix the wafer, and they are widely used in spinners for resist coating, spin driers, positioning devices, and other production equipment.

However, it is desired that such wafer chucks be capable of supporting wafers softly, so that they are neither deformed nor fractured.

[Related Technology]

Progress in the field of semiconductor devices such as IC was accompanied by a gradual increase in the diameter of semiconductor wafers, and the conventional wafers with a diameter of 3-4 inches have been replaced with 6- and 8-inch wafers.

FIG. 3 shows a recently suggested wafer chuck for chucking such large wafers. FIG. 3(a) is a cross-sectional view. FIG. 3(b) is a plan view as viewed from the chucking surface. The AA' cross section of the chuck presented in figure (b) is shown in figure (a).

As shown in the figure, a vacuum suction orifice 1 is provided in the center of the chucking surface, a plurality of radial grooves 2 (four in the example shown in the figure) are formed in the chucking surface and a plurality of ring grooves 3 passing through the radial grooves are formed over the entire surface. For example, in a wafer chuck for chucking 6-inch wafers, the chucking surface has a diameter of 150 mm, 10-12 ring groves 3 with a groove width of 1 mm are provided in the chucking surface, and the wafer is sucked and vacuum chucked under a reduced pressure of about 200 Torr. The vacuum chucked wafer 10 is also shown in FIG. 3(a).

When the wafer diameter was small, the wafer was held with a wafer chuck provided only with a vacuum suction orifice in the center. However, the large-diameter wafers which are presently employed are difficult to hold with such a structure, and wafer chucks have come to use which additionally have grooves passing through the vacuum suction orifice.

[Problems Addressed by the Invention]

However, with the chucking method by which a wafer is vacuum chucked with such a wafer chuck, chucking is carried out with a strong suction force. The resultant problem is that the wafer is deformed or, in worst cases, cracked. Further, when vacuum chucking is conducted in combination with reagent treatment or water washing, the reagents or water can flow back into the vacuum source. In addition, there is a risk of a mist flowing into the vacuum source and contaminating the wafer.

In order to resolve the aforementioned problems, a wafer chuck of Bernoulli's system shown in FIG. 4 was recently suggested. In this system, by contrast with the above-described one, a gas ejection orifice 4 is provided in the center of the chucking surface and high-pressure gas is blown to the circumference of the wafer 10. With such a system, gas is ejected from the wafer circumference and a negative pressure is created between the chuck and the wafer and the wafer is sucked back toward the chuck.

With the wafer chuck of the Bernoulli's system, problems associated with deformation or cracking of the wafer by chucking are alleviated and the risk of reagent or

water flowing backward is eliminated. However, because the wafer is held in a floating state, the wafer is unstable. Furthermore, because the wafer is not reliably chucked, it cannot be rotated. Wafer rotation has been used to provide for uniform distribution in a resist coating or etching process. For this reason, the wafer chucks of the above-described system have not reached a stage of practical use.

The present invention resolves the above-described problems and provides a wafer chuck allowing for reliable chucking and causing no deformation or cracking.

[Means to Resolve the Problems]

The above-described object is attained by providing a wafer chuck comprising a chucking surface with a surface area less than that of the wafer which is to be chucked, wherein radial grooves are provided in the chucking surface, a portion on the circumference of the chucking surface, which faces the wafer which is to be chucked, is recessed, a plurality of gas ejection orifices are provided in the recessed portion, gas is ejected from the gas ejection orifices in the direction of wafer edge, and the wafer is chucked to the chucking surface.

[Operation]

Thus, the present invention provides a wafer chuck in which a wafer is chucked by ejecting gas on the circumference of the chucking surface and actuating the so-called aspirator function.

As a result, an adequate suction force can be obtained, chucking can be conducted softly and reliably, deformation and cracking of the wafer is prevented, and the wafer can be rotated.

[Embodiments]

The present invention will be described hereinbelow in greater detail based on embodiments thereof illustrated by the appended drawings.

FIG. 1 shows a wafer chuck in accordance with the present invention. FIG. 1(a) is a cross-sectional view, FIG. 1(b) is a plan view from a chucking surface. The BB' section in FIG. 1(b) is shown in FIG. 1(a).

FIG. 1(a) also shows a wafer 10 which is being chucked. As shown in the figure, gas under a pressure of about 4 kg/cm^2 is supplied from a gas inflow orifice 12 provided in the rear surface of a chucking surface 11, and the gas is ejected from a plurality of gas ejection orifices 13 located on the periphery of the chucking surface. The gas ejected from the gas ejection orifices 13 is ejected toward the peripheral edge of the wafer. As a result, an aspirator function is realized, the air located between the wafer 10 and the chucking surface 11 flows out in the circumferential direction of the wafer, a reduced pressure is created between the chucking surface and the wafer, and the wafer is chucked to the chucking surface.

Even after the chucking, air continuously flows out in the circumferential direction of the wafer from radial grooves 14 provided in the chucking surface and

concentric circular ring grooves passing through the radial grooves. As a result, the negative pressure is held and chucking of the wafer is maintained.

Dimensions are described below. For example, with the wafer chuck for chucking a wafer with a diameter of 6 inches (150 mmø), a 10-mm recess is provided on the circumference of the chucking surface with a diameter of 120 mmø and 70-80 gas ejection orifices 12 are provided in this portion. A partial cross-sectional view of the structure is shown in FIG. 2 (this figure illustrates a state in which the wafer 10 is chucked). The gas ejection orifices 12 have a diameter of 1.2 mmø, the height L of the recess is 0.7-1 mm, the depth of grooves 14, 15 in the chucking surface 11 is also 0.7-1 mm, and the groove width is about 1 mm. Those dimensions somewhat differ depending on the wafer diameter and pressurization conditions.

Using the above-described wafer chuck in accordance with the present invention makes it possible to provide for softer chucking than that attained with a vacuum suction chuck and contamination of the wafer by a backflow of a solution or mist is prevented. Furthermore, the wafer can be rotated. Another advantage is that if nitrogen gas is used as the pressurized gas, then the nitrogen gas is constantly used in the wafer processing chamber, and the vacuum source or vacuum piping for the conventional vacuum suction chuck are unnecessary.

[Effect of the Invention]

As described hereinabove, with the wafer chuck in accordance with the present invention, the wafer is chucked in a deformation-free state and a significant contribution is made to quality improvement and increase in yield of IC.

4. Brief Description of the Drawings

FIGS. 1(a), (b) are a cross-sectional view and a plan view of the wafer chuck in accordance with the present invention.

FIG. 2 is a partial cross-sectional view thereof.

FIGS. 3(a), (b) are a cross-sectional view and a plan view of the conventional wafer chuck.

FIG. 4 is a cross-sectional view of another conventional example.

Keys:

10 – wafer, 11 – chucking surface, 12 – gas inflow orifice, 13 – gas ejection orifice, 14 – radial grooves, 15 – ring grooves.

FIG. 1

Wafer chuck in accordance with the present invention

FIG. 2

Partial cross sectional view

FIG. 3

Conventional wafer chuck

Fig. 4

Other conventional wafer chuck